

Cloth Weft Counter System by Laser Light for Industrial Use

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Light scattering has been applied to a cloth weft counting system, which has been verified for an industrial use. A sheet-like laser light with the length, l , and width, w , is irradiated on the Moire pattern of cloth with the pitch, p . The best results have been obtained with $d = (1/3)p \sim (1/2)p$ and $l = 5w \sim 20w$ depending on the Moire pattern. The present system consists of semiconductor laser as a light source, PIN photodiode as a light detector, an amplifier, a digitizer (ΔV detector) to transform a pseudosine wave to a square wave, an electronic counter and a display. The accuracy of the system has been found to be above 99% under the best condition. The counting frequency of the cloth weft is above 10kHz to be enough for a practical use.

Key Words: Counter system, Cloth weft, Moire appearance, Laser, Industrial use

1. Introduction

In the textile industry, two major parameters are left to be studied in the production process, the cloth length and the cloth weft density which is given by a weft numbers per unit length. The former is the business basis between a seller and a buyer and the latter determines aspects of the cloth, soft or rough. The length of the cloth changes with the tension and the history after weaving such as the stored time and the stored condition. Those two parameters can be precisely determined by counting the weft number and measuring the cloth length simultaneously. Since the weft density is given in the weaving process, the cloth length can be determined by measuring the weft number.

The purpose of this paper is to improve the previously reported system¹⁾ for an industrial use. The present system provides a good accuracy and a high counting speed enough for various types of knitting machines.

2. Method and experimental system²⁾

We have proposed the light attenuation method.¹⁾ In this system, a light source and a light receiver were set up on the opposite side of the cloth. Then, the present method can be effectively used only when the cloth is thin and light passes through the cloth with a little attenuation.

On the contrary, the principle of the present method is based on the light scattering on the cloth. The method can then be applied to a thick cloth such as a light shielding curtain as well as a thin cloth. Further, it can be also applied to the cloth of a different Moire appearance of head and tail, to which the light attenuation method can not be applied. The light scattering method can, thus, be widely applied. The method, further, has an advantage over the light attenuation method from a practical point of view, that the sensor head including both light source and light receiver can be incorporated in a body since they are set up on a same side to the cloth.

Figure 1 shows a sensor head (a) and a whole system (b) of the method. A sheet-like laser light illuminates the cloth with parallel to a Moire appearance of the cloth as shown in Fig. 1 (a). The scattered laser light is received by a PIN photodiode. A difference in direction between the sheet-like laser light and the Moire appearance line (for short "Moire line") may cause a complicated wave form of the received intensity and then yield a count error of the Moire line number. This will be discussed in 4. The output signal of the photodiode is then led into a counter system consists of an amplifier, digitizer (called ΔV detector) and counter. The ΔV detector reforms sine-like wave form to a square waves. The Moire line can then be exactly countered and then expressed on the display. Thus, the method in this paper is fundamentally to count the Moire lines. The sine-like wave results only from the Moire appearance of the cloth surface and does not depend on the speed of cloth motion. This may be one of the merits over other methods.

The weft density and the Moire density are usually different. There is, however, a definite relation between them depending on the weaving manners, such as plain weave, twill weave and sateen weave. We can then determine the weft number from the Moire line number.

3. Experimental results²⁾

Figure 2 shows representative examples of the clothes having various Moire appearance. This Moire appearance results from the strength of the scattered light intensity due to an uneven cloth surface and yields sine-like wave for the output signal on the PIN photodiode. In each of the photograph, the left-hand side photographs show the head of the cloth and the right-hand side the tail. The black points at the bottom in each photograph show a measurement for a 1mm length. The Moire appearances of the head and tail in each cloth are quite different as seen in this figure except for (a). These clothes are all knitted together with thick thread bundled by some fine threads. The thick lines in

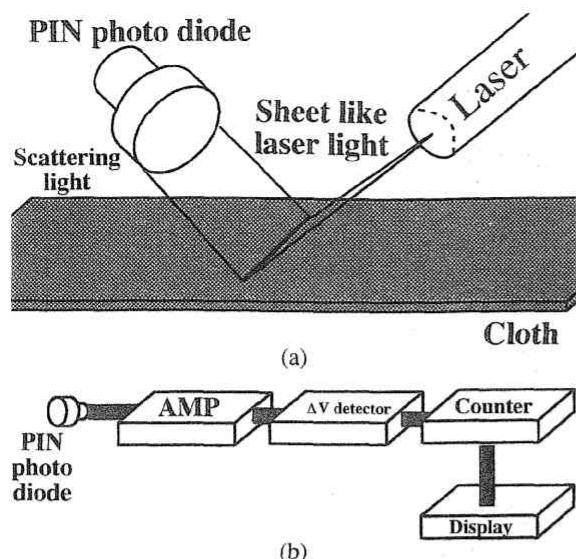


Fig.1 Experimental system. (a) Sensor head and (b) Signal processing system.

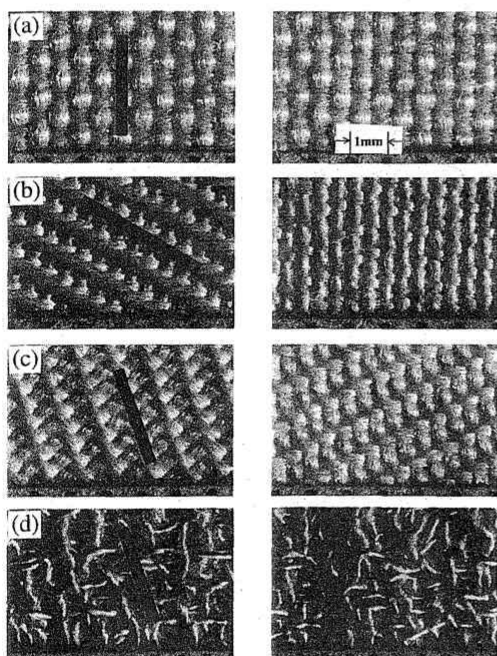


Fig.2 Photographs of the cloth samples. Left shows the head and the right the tail. (a) Examples of plane weave, (b) twill weave, (c) sateen weave, and (d) a towel.

each figure show the laser light cross-sections irradiated on the cloth. The line must be parallel to the Moire line, as much as we can, to obtain sine-like wave intensity. This enables us count the Moire line numbers accurately. A slight difference in directions between both lines may lead to a miscount of the Moire line numbers as discussed in 4.

Figure 3 shows the output signals of the scattered light intensity received by PIN photodiode (upper side) and the square waves reformed by ΔV detector (lower side). Figure 3 (a) was obtained using a cloth in Fig.2 (a) and Fig.3 (b) using a cloth in Fig.2 (b), respectively. These were obtained under the ideal condition, that is, both the line direction of the sheet-like laser light and the Moire line direction of the cloth are parallel with each other. The value of the light output depends only on the contrast of the

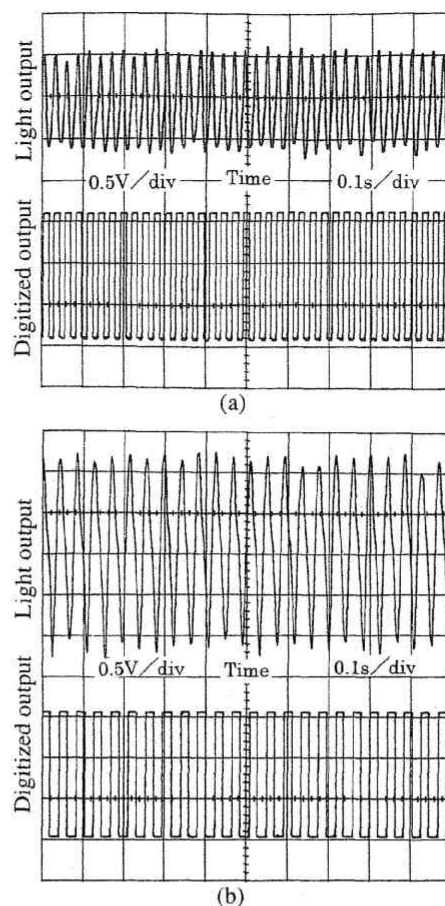


Fig.3 Wave form of the scattered laser light intensity at the PIN photodiode (upper side) and the square waves reformed by ΔV detector (lower side). (a) and (b) correspond to the experimental results of (a) and (b) in Fig.2. These results were obtained where sheet-like laser is parallel to the cloth Moire line as shown 1 in Fig.4.

Moire appearance in this best condition. Such sine-like wave is reformed to a regular square wave by the ΔV detector as shown in this figure. The number of Moire line obtained by such wave accurately agrees with the one by the microscopic observation.

We have examined for ten kinds of clothes and found out that the miscount rate was below 1% for all clothes with a few marked exceptions which have not a clear Moire appearance such as in Fig.2 (d). We are now under study in this problem.

We have further examined the system for the industrial use. The system was set up in a manufacturing plant. Table I shows an example. The error between mean value and number of Moire lines per unit length was found to be less than 1% in each measurement. The speed of the cloth movement was 75m/min. The cloth used was the one described in Fig.2 (b).

The maximum counting frequency was found to be above a few tens kHz in the best condition without the interpolation method discussed in section 4. It is limited by a processing speed of the computer to interpolate a complicated wave-form to a sine-like wave-form. Even in this case, it can be above 10 kHz.

4. Discussions

4.1 Improvement of the accuracy

The accuracy of counting depends basically on the degree of

Table I Measured numbers of cloth Moire line in industrial use and error rate from the mean value (Cloth speed: 75m/min).

Cloth Length (m)	Number of Moire Line	Moire Line Number in 1m	Error Rate from Mean Value (%)
115	117878	1025.03	- 0.78
120	124600	1038.33	0.51
117	120800	1032.48	- 0.06
118	122000	1033.90	0.08
117	120300	1028.21	- 0.47
118	121400	1028.81	- 0.41
117	121900	1041.88	0.85
119	122600	1030.25	- 0.27
117	121380	1037.44	0.42
117	120000	1025.64	- 0.72
117	120580	1030.60	- 0.24
117	121560	1038.97	0.57
116	120444	1038.31	0.51
Mean Value		1033.07	

the parallel between both line directions of the sheet-like laser light on the cloth and of the Moire appearance. Figure 4 shows a schematic diagram of this relation. The cross-section of the sheet like laser light of width, w , and length, l , illuminates the cloth of Moire line pitch p , where three cases 1, 2 and 3 are shown as the examples. It was found from the experiment that the high contrast sine-like wave can be obtained when the width is between $1/2$ and $1/3$ of the Moire line pitch, p , and the length is between 5 and 20 times of the width.

Figure 5 shows a similar waves to Fig.3, which corresponds to Fig.2 (c). They are complicated in particular Fig.5 (b) as compared to Fig.3. An amplitude decrease of the sine-like waves may be due to a slight decrease of parallelism between both lines as shown in Fig.4 (2) and (3). The slight decrease of parallelism is unavoidable in an industrial application because of a twist of the Moire appearance caused by a unbalanced tension of the cloth. It does not, however, cause a miscount since a correct square waves are obtained as shown in Fig.5 (a). On the contrary, a large distortion of the sine-like waves due to a lack of parallelism may cause a miscount as shown in Fig.5 (b). But the lack of parallelism was found to be rather small in the experiment at the manufacturing plant as shown in Table I. The distortion may, rather, be due to the lack of contrast of the Moire appearance.

The problem of the degree of parallelism may be easily solved by the use of the sheet-like laser light with a short length. It was, however, found from the experiment that the contrast of the scattered light intensity was also decreased. Thus, it is essential to find a point of compromise between the length l and the pitch p . This is, however, not an essential solution.

Three essential methods may be considered to solve this problem. The first is to reform the complicated wave form to a sine-like wave by the interpolation method. This can be done by a software technique and may be simplest and effective method from a practical point of view. The second is to use two PIN photodiodes placed at different position. In this case, one photodiode may, at least, receive a right sine-like wave even if the other receives a complicated wave. The count is always done by a right sine-like wave using a OR-logic circuit. Thus, even if each photodiode has a miscount rate of 5%, both photodiodes may reduce a miscount rate to 0.25%. The third is to adjust the

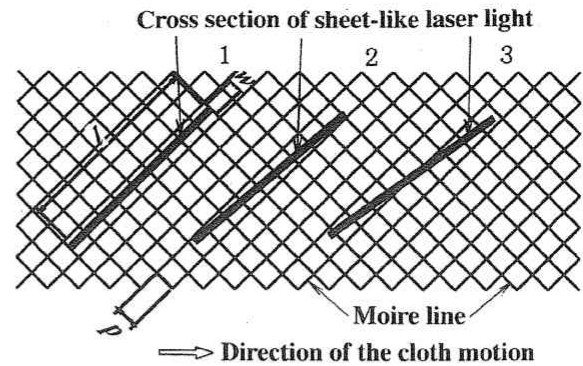


Fig.4 A relation between directions of the sheet-like laser light and the Moire line. 1 is a case of perfect parallelism, 2 a slight lack of parallelism and 3 a lack of parallelism.

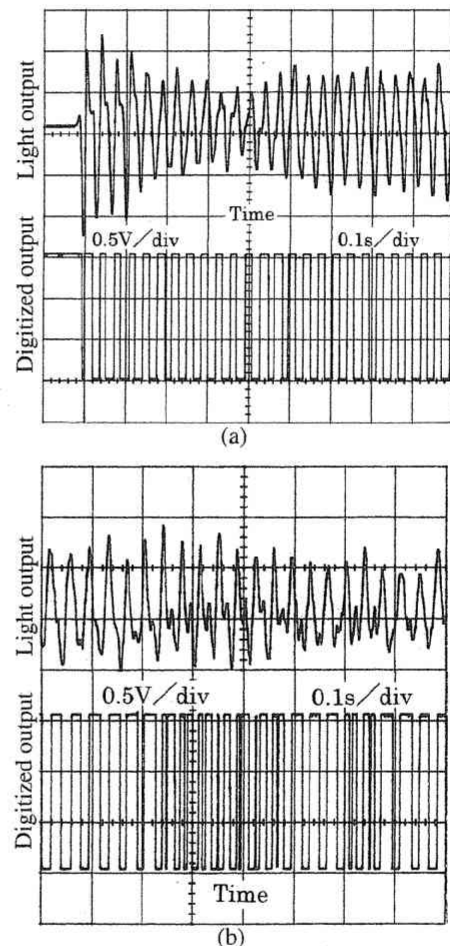


Fig.5 Wave form of the scattered laser light intensity and corresponding square wave form for the cloth in Fig.2 (c). (a) shows a case where sheet-like laser is slightly inclined to Moire line as shown 2 in Fig.4 and (b) rather inclined to Moire line as shown 3 in Fig.4.

laser light direction parallel to the Moire line of the cloth by means of feedback system, where a signal of a phase difference of the light intensity received on both photodiodes is used to rotate slightly the direction of the laser mounted on a rotary machine.

4.2 System for industrial use

The sensor head is usually fixed at a position and the cloth

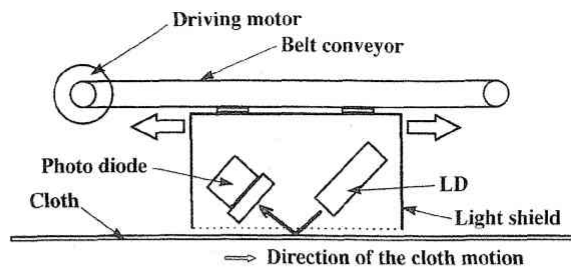


Fig.6 Proposed cloth weft counter system using laser light for industrial use.

moves in an industrial use. It has, however, to be moved when the cloth is at rest. Figure 6 is a proposed system acceptable for these two purposes. The laser mounted on the belt is moved at a constant speed by a motor drive when the cloth is at rest and is fixed at a proper position when the cloth is moved. The laser and the PIN photodiode are confined in a light shielding box to eliminate the back ground light noise.

5. Conclusion

An optical counter system for the weft number of cloth is de-

veloped for industrial use by means of scattered laser light. The system features;

- (1) applicable to various kind of clothes,
- (2) applicable to both cases, *i.e.*, cloth is at rest and moved,
- (3) accuracy exceeds 99%,
- (4) a counting frequency of above 10kHz.

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